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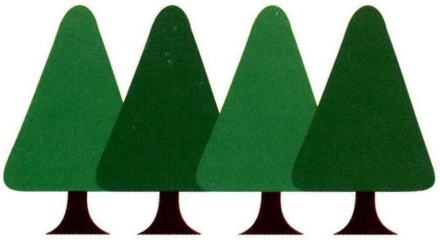
FOREST HEALTH



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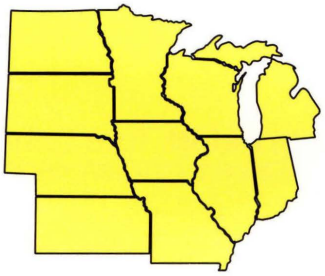

NORTH CENTRAL STATES

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I. Our forest

Introduction

This publication provides basic information about forest health to land managers, extension personnel, students, educators, those involved in setting public policy, and the general public.

There are some basic, scientifically quantifiable variables that most people consider to be important when measuring the health of forests. These include tree mortality, tree growth, reproduction, injury to trees, condition of the tree crowns (the portion of the tree where the leaves are), and species composition of the forest area. However, forest health is not always easy to define. Determining whether a given forest is healthy also involves perceptions, judgements, and personal standards.

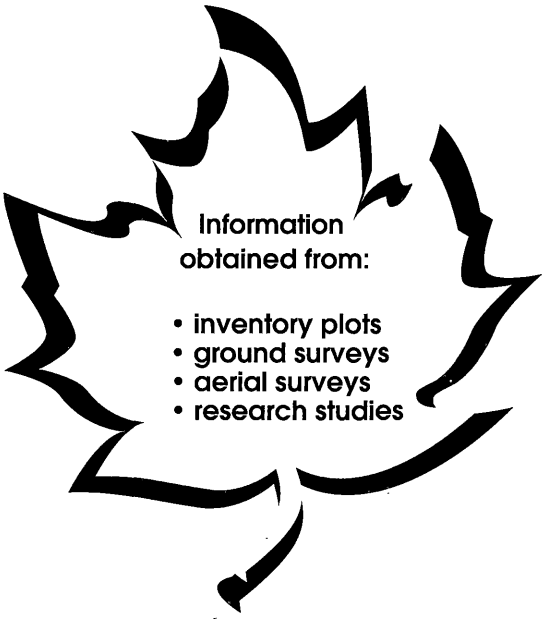
In this booklet we describe:

- Part I: characteristics of rural and urban forests in the North Central Region and how forest health is being studied,
- Part II: some recent key results for the North Central Region from the National Forest Health Monitoring Program,
- Part III: factors that place stress on our forest and ways forest health has recently been affected by these factors.

Finally, on the back cover you will find a list of helpful phone numbers that will aid you in obtaining further information if you are interested.

How do we know about the health of the forest?

No single measurement can summarize forest health. Instead, we need to study many indicators which together serve as a reflection of existing conditions. Repeated monitoring of the forest over time allows us to identify changes and trends in forest conditions.



Information about forest health is obtained in a variety of ways. The USDA Forest Service conducts a program called Forest Inventory and Analysis, which provides information in each state on rates of tree growth and death, harvesting, and changes in forest area and tree species. The Forest Service and state agencies also make regular ground and aerial surveys of forest pests and damage, both in permanent plots and in surrounding forest areas. Universities, private industry, and environmental groups cooperate with governmental agencies on a variety of forest research projects.

One major program aimed at understanding forest health is a joint federal/state program called the Forest Health Monitoring Program. This national program began in 1990 and is under the administration of the USDA Forest Service. It includes the active participation of state foresters, other federal and state agencies, and universities. The program goal is to monitor, assess, and report on the status, changes, and long-term trends in the health of our nation's forests.

The Forest Health Monitoring Program is composed of a network of permanent plots and other forest areas that are regularly visited to evaluate a number of indicators of forest health. These include tree vigor, crown condition, and signs of tree damage. Additional data are recorded for a subset of the plots, including monitoring the effects of the gaseous pollutant ozone on susceptible plants, noting presence and abundance of lichens (life forms that are a combination of algae and fungi, some of which are pollution sensitive), and recording information about the composition and structure of the plant community. Permanent plots have been established in 24 states. Long range plans are to eventually provide coverage of all forested areas in the United States. In the North Central Region, states currently participating in the Forest Health Monitoring Program are Illinois, Indiana, Michigan, Minnesota, and Wisconsin.

A healthy forest gives us . . .

• Biodiversity: It is very important to maintain diversity of living organisms in our forest ecosystems. Diversity gives ecosystems stability and helps them deal with various stress factors. From a human perspective, having a variety of organisms present is aesthetically pleasing. In addition, many species may in one way or another benefit people and be of use to us. Some of these uses we already know about, but there also may be other undiscovered uses.

The best way to encourage high levels of biodiversity is to have a good mixture of habitats within our forests. This means maintaining a combination of various forest types, tree ages, and species compositions. Healthy forests usually have a mosaic of stand conditions present.

• Habitat and wildlife: Residents in the United States spend over $6 billion annually on trips where wildlife is the major attraction. Wildlife use different parts of the forest for food, shelter, and protection. Both living and dead trees are important for various wildlife species. Many species are quite specific in the kinds of conditions they need to thrive and therefore they are often associated only with a particular type or age of forest stand.

• Protection of soil: Forests help to prevent erosion, or the wearing away of soil through the action of wind and water. The canopy of leaves in the forest shields the ground from the hard pounding action of rain, slowing and softening its fall to the forest floor. Plants also contribute organic material to soil which helps soil absorb and hold water. This prevents the water from running off rapidly across the surface, carrying soil with it. Less visible than the movement of large soil particles but equally important, plants in the forest help to prevent the loss of important nutrients from the soil. They keep nutrients from being washed away across the surface of the land by rainfall. Also, by absorbing nutrients efficiently with their large spreading root systems they prevent nutrients from being transported by water deep down into the soil where they would be unavailable to the plants and animals that need them.

• Protection of water and air: Forests filter large amounts of water and air which flow through them. This filtering action helps trap some kinds of pollutants and remove them from continued circulation. Forests are important in increasing the amount and quality of drinking water available to people and also are important in providing us with oxygen.

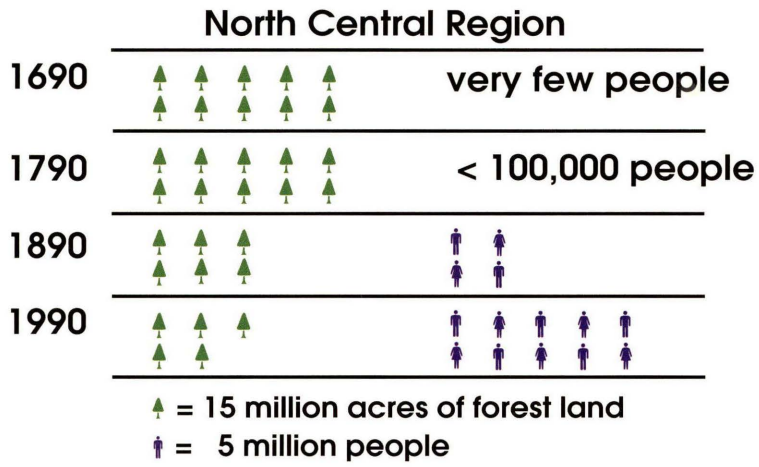
• Products: Forest trees provide us with lumber for building and wood that is used to make a variety of products such as furniture, containers, and paper. The annual value of wood products is approximately $3 billion in both Indiana and Missouri, $8 billion in Minnesota, $9 billion in Michigan, and $15 billion in Wisconsin.

• Jobs: Forests are linked directly or indirectly to a large number of jobs. There are over 60,000 people employed in forestry-related jobs in Missouri, 80,000 in Indiana, 110,000 in Minnesota, 190,000 in Wisconsin, and 150,000 in Michigan.

• Recreation: People use forest areas for a great many recreational activities. Hiking, camping, hunting, fishing, skiing, bird watching, and photography are activities people like to do in forests. People value having forests available for these and other recreational uses and enjoy the shelter, shade, and spiritual comfort that the forest provides. Over 830 million visitors were recorded using national forest lands for various recreational activities in 1996.

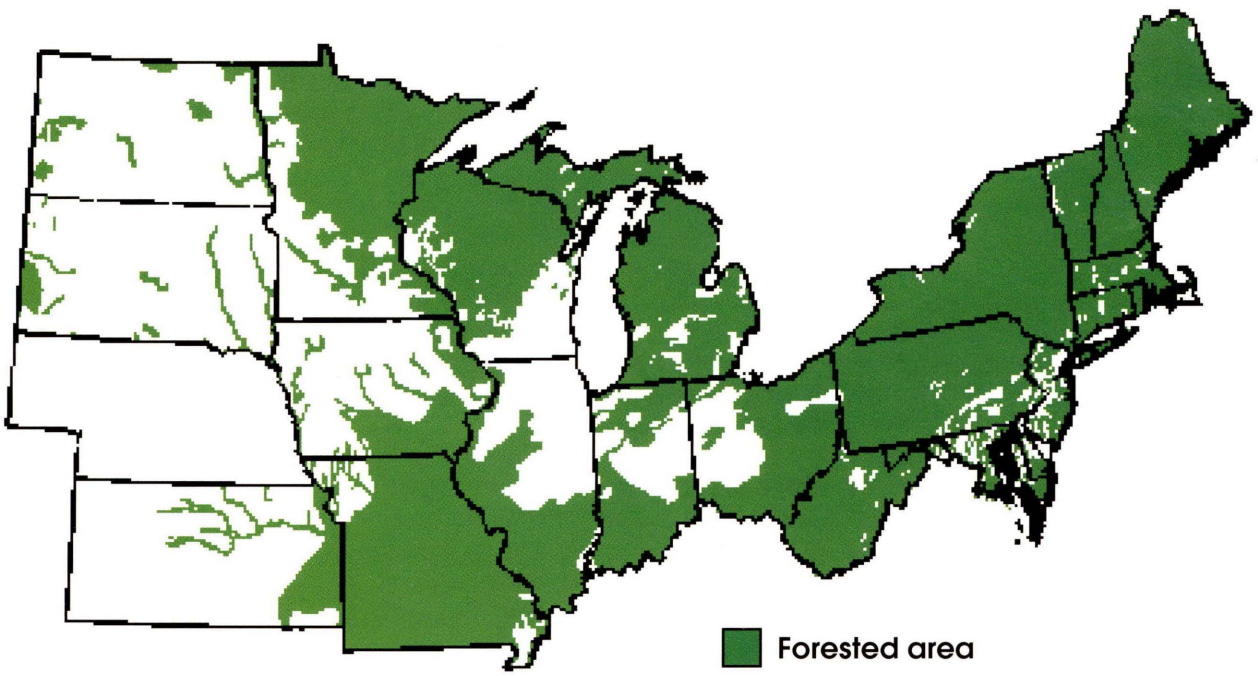
• Aesthetics: Forests enhance the beauty of the landscape, providing rich and varied scenery enjoyed by tourists as well as by those who live near the forests. Activities centering around appreciation of the aesthetic nature of forests, such as autumn color touring, are common in the North Central Region. These activities draw a great many visitors to forest areas annually. Forest related tourism and recreation in Michigan accounts for 50,000 jobs, and contributes $3 billion annually to the states economy.

How much forest is there?



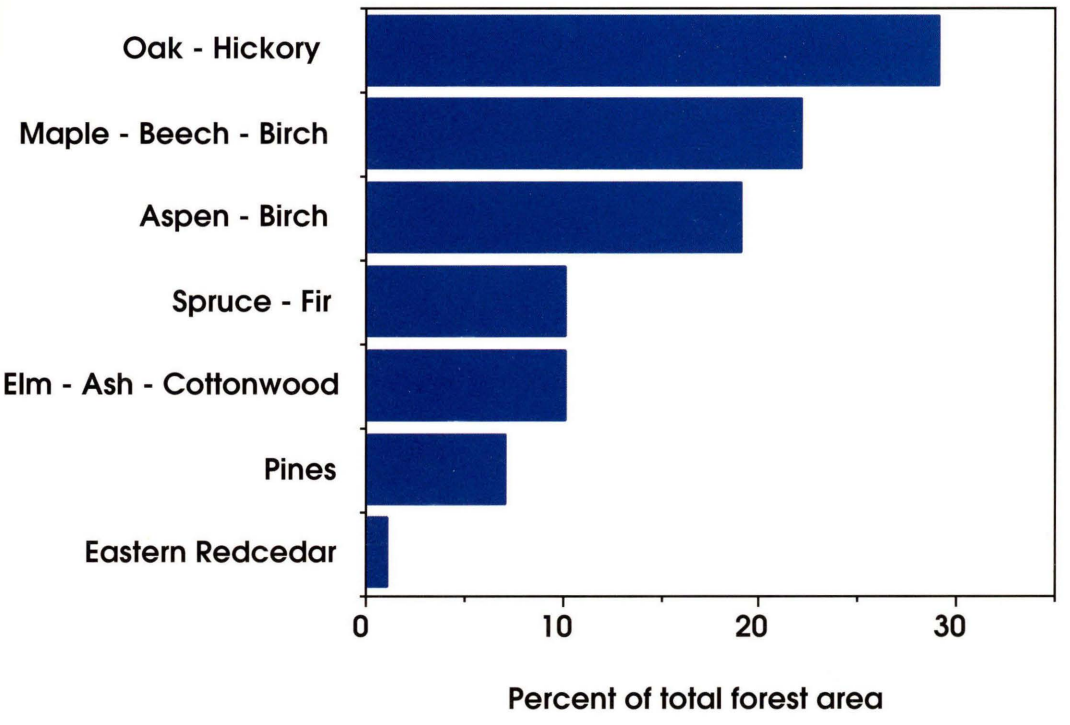
Human population in the region has increased sharply since the 1600s. During this same time period, forest area has decreased as land has been cleared for agriculture, housing, and other purposes. In the future, human population levels will likely continue to increase, and the forest will be required to meet additional demands for resources as well as facing increasing levels of fragmentation as more land is developed. Currently, the total forest area in the North Central Region is 74 million acres.

Where is the forest?

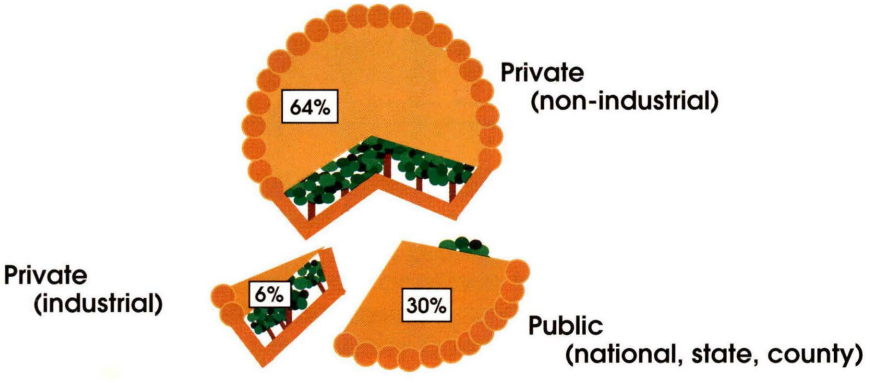


What kinds of trees make up the forest?

The forest can be divided according to the types of trees that dominate in various parts of the landscape. In the North Central Region, the most common forest types are:



Who owns the forest?



Because of the large amount of non-industrial private forest land, it is very important for private landowners to practice good stewardship in order to help safeguard forest health.

Trees in cities

When we compare urban trees and forest trees, we find that there are both differences and similarities. Urban trees:

- have higher average value as individuals than forest trees do.
  Total value of urban trees in the United States: $250 billion

- are fewer in number than forest trees.
  Size of urban forest in the United States: 93 million acres
  Number of urban trees in the United States: 610 million

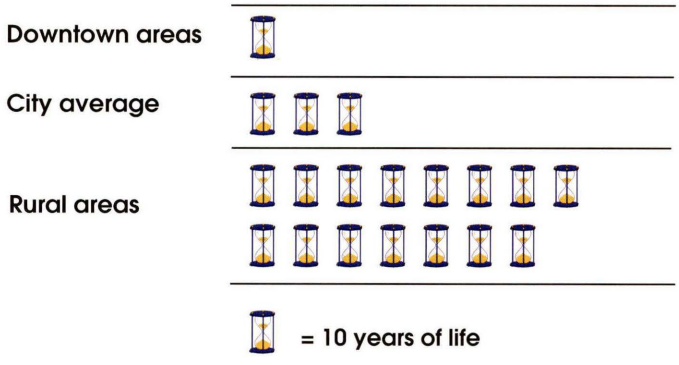
- provide shade for buildings and people.

- block noise.

- provide aesthetically pleasing scenery in urban areas.

- have shorter average life spans than forest trees.

  Average life expectancy of urban trees compared to rural trees in the United States:



Most frequently planted urban trees in the United States:

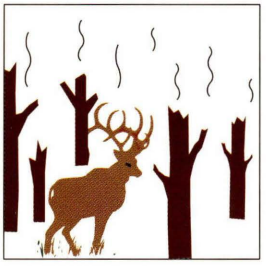
Norway maple
flowering pear
linden
green ash
honey locust
red maple

Common stresses on urban trees:

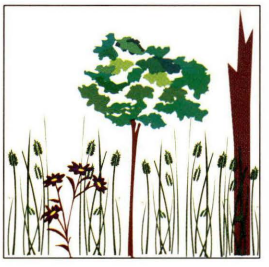
pollution
salt
nutrient deficiencies
soil compaction
drainage problems
construction
insects
diseases

Changes in the forest over time

Forests are in a constant state of change. Disturbances in the forest--such as windstorms, fires, major pest attacks, land-use conversions, or logging operations--all are important factors that lead to changes in the forest. Yet even without such a disturbance, the composition of the forest will gradually change over time as the forest community matures. The particular changes that take place are influenced by the amount of light, nutrients, and water available to the plants. The gradual change in species composition and replacement of some forest species with others over time or after a disturbance is called *succession.*



Disturbance may remove some or all of the existing vegetation, including eliminating a particular species.



Sun-loving, fast growing plants such as grasses, wildflowers, and trees like aspens and white birches are the first plants to establish in the disturbed area. These plants are called *early successional species* or *pioneer species.*

As the pioneer trees become larger and shade the area, other tree species begin to grow up in their shade. The particular plant community that will replace the early successional species will depend upon the amount of nutrients and water available to the plants. For example, if the early successional species at a site are aspen and white birch and the site is very wet, we would expect balsam fir and white spruce to be the next tree species at the site. If the site had only moderate moisture, we would expect red oak and red maple. If the site had less moisture, we would expect white pine.

Eventually, shade-tolerant species or species otherwise better suited for the current site conditions may take over as the short-lived pioneer species die out. The community will continue to undergo gradual changes in species composition, which will lead to a final, relatively stable community composed of species highly adapted to the growing conditions. These species are called *late successional species*, and this community sometimes is referred to as the *climax community*.

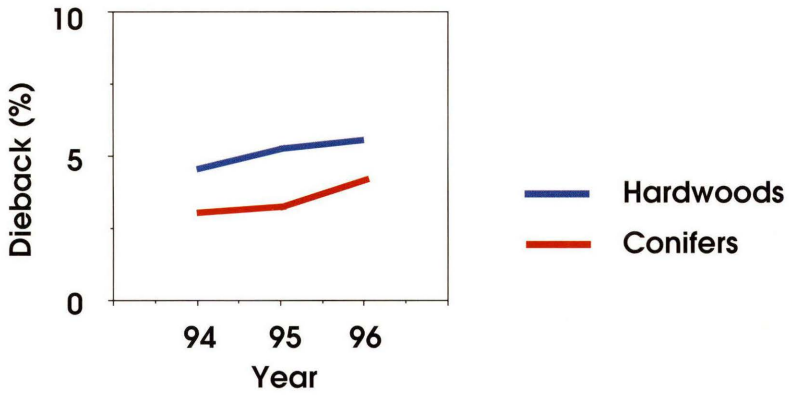
At any point along this successional sequence disturbance may occur, which will then set the forest back to an earlier stage in succession. Various harvesting techniques or pests could accelerate succession if they select against pioneer species.

II. What about tree health?

(All data summarized from Forest Health Monitoring plots in the North Central Region.)

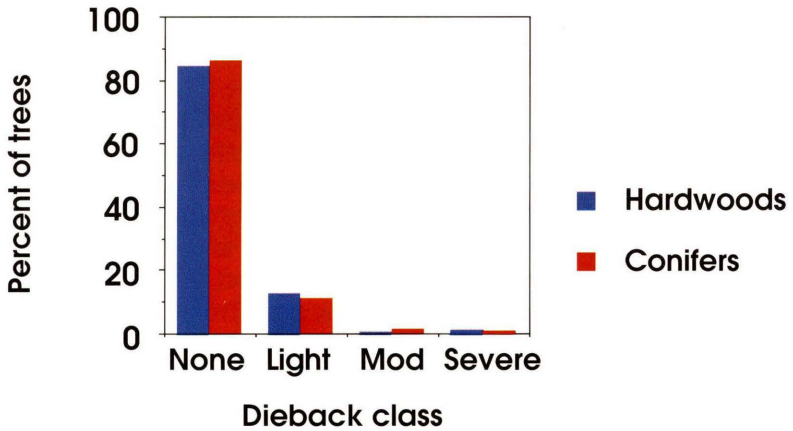
Crown dieback

One measure of tree health is *crown dieback.* This is one of the variables measured in the Forest Health Monitoring plots. Dieback is measured as the percent of branch tips in the crown that are dead. However, in making this measurement branch tips that are dead due to shading or competition are not included because they are dead due to the normal processes of tree growth. Therefore, the measurement only includes dead branch tips in the upper portion and outer edges of the live crown--these branch tips would generally be alive if the tree were not experiencing stress. Dieback amounts differ among tree species. Some species will normally show a small amount of dieback. While such small amounts of dieback are not considered to be a problem, larger amounts of dieback indicate that a tree is under extra stress. Trees with high dieback values have a reduced amount of leaf area for producing food. Dieback has varied among years and between hardwoods (e.g., maple, oak) and conifers (e.g., pine, fir):



Hardwood trees tend to have higher amounts of dieback rates than conifer trees. This is partly due to physiological differences between these two groups. The energy needed to grow a completely new set of leaves each year and the additional effect that drought has on hardwood trees is partly responsible for their higher dieback rates.

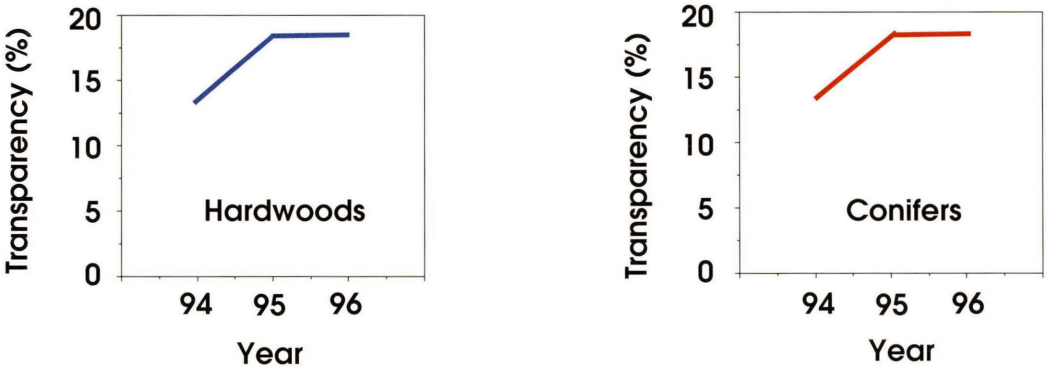
Dieback also can be described as none (0-5%), light (6-20%), moderate (21-50%), or severe (51-100%). In a detailed look at the data for 1996, we can see the percent of the trees that were in each of these classes:



Over 97% of all trees in 1996 were classified as having either no crown dieback or light crown dieback. More than 6% of the American elm trees in the plots were in the moderate and severe dieback classes. This is due in many cases to the effects of Dutch elm disease.

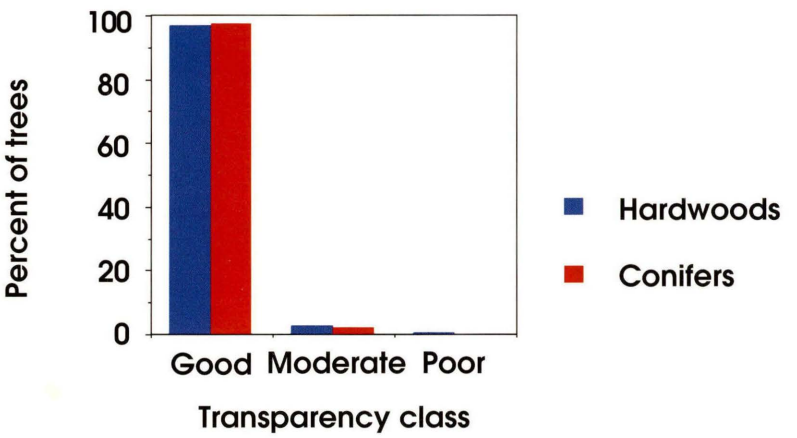
Foliage transparency

Foliage transparency also tells us about tree health. This variable measures the amount of light that shines through the live portion of a tree's crown as a percent of total light that would be visible if the light were unblocked. Light comes through the crown where leaves are missing, damaged, smaller, or less numerous than normal. Transparency values differ among tree species and are affected by the tree's shape and growing conditions. Higher transparency values than normal for a species indicate that the tree has less leaf area to catch sunlight for photosynthesis. High transparency values may result from insects feeding on tree leaves and damaging them, diseases causing leaves to fall or become damaged, or other stresses such as drought or frost that can affect a tree's leaves. Shown below are transparency values for hardwoods and conifers:



Transparency fluctuates from year to year, as seen in the above graphs. This variation is natural and is influenced by a variety of factors including stress caused by drought and pest outbreaks. Transparency would have to change by more than 20% for the difference to be significant.

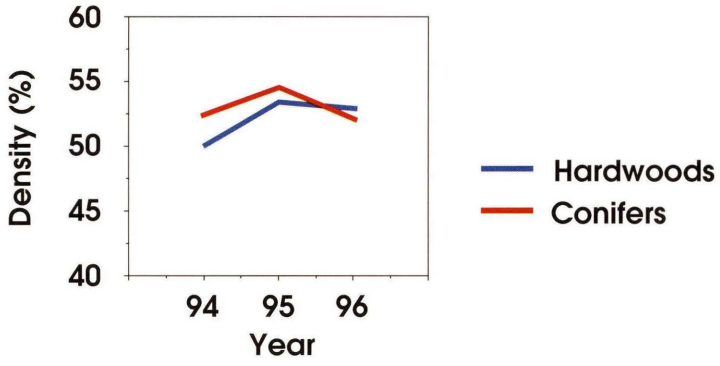
Transparency can be described as being good (0-30%), moderate (31-50%), or poor (51-100%). In a detailed look at the data for 1996, we can see the percent of the trees that were in each of these classes:



About 97% of the trees were classified as having good foliage transparency in 1996. Trees having only moderate or poor transparency values were primarily tamarack and black ash. Tamarack normally has high transparency due to its feathery foliage, and many black ash have experienced several years of dieback and decline due to adverse soil moisture conditions, frost, and leaf diseases.

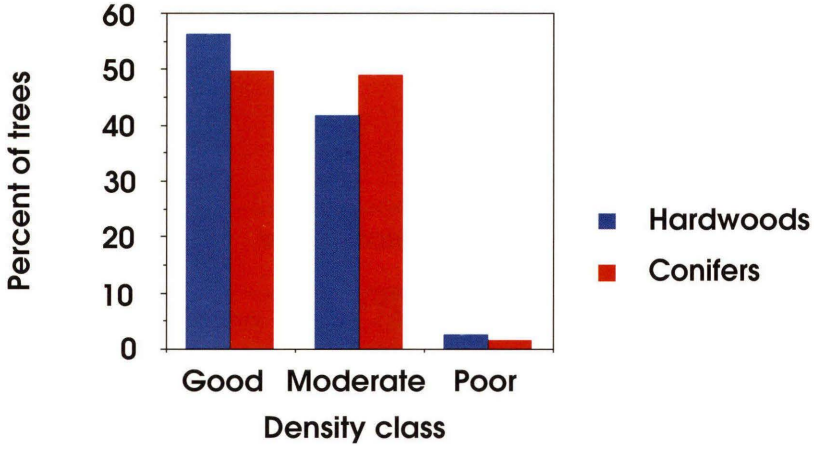
Crown density

Another way to measure tree health is *crown density.* Density tells us the amount of plant material, such as leaves, branches, and fruit, that block skylight from shining through the tree crown. It is measured as the percent of total light that is blocked by tree material. Unlike transparency, this measurement takes into account both the live and dead parts of the crown rather than just the live portion. Because density measurements consider all parts of the crown, density is not a perfect mirror image of transparency. Like transparency, density differs among tree species and is affected by the tree's shape and growing conditions. For transparency, high values indicate poorer tree condition. For density, however, high values indicate that the tree has a large amount of leaf material available for photosynthesis and has growing conditions that enable full and symmetrical growth. Low density values indicate poor amounts of foliage, a thin crown, or a missing section of crown and may result from stresses such as insect and disease damage or other environmental factors such as drought, wind, competition, or soil compaction. Density fluctuates from year to year as shown in the graph below:



This variation in density is natural and is influenced by a variety of factors. One of the most important factors influencing the variation is drought. Pest outbreaks also can lead to density change. The minor fluctuations seen in the graph above appear to be associated with these types of stress events. Density would have to change by more than 20% for the difference to be significant.

Density also can be described as being good (51-100%), moderate (21-50%), or poor (0-20%). In a detailed look at the data for 1996, we can see the percent of the trees that were in each of these classes:

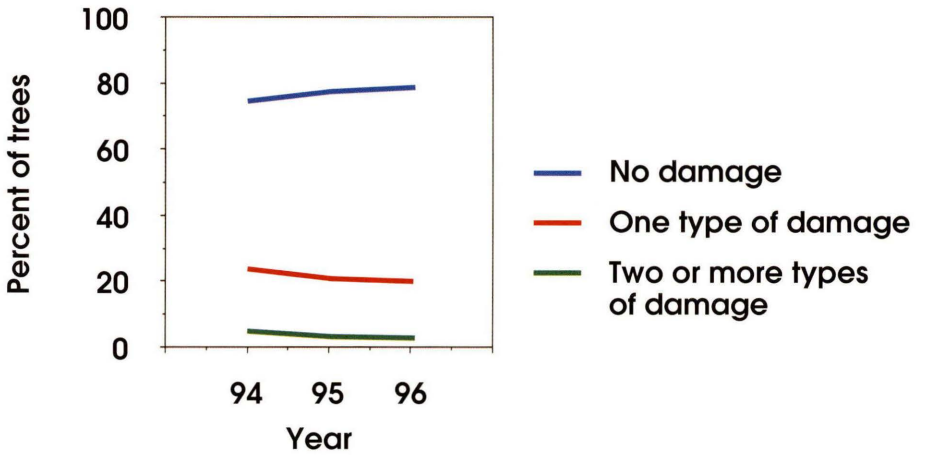


Most trees are doing very well in terms of foliage density. Over 98% of all trees were classified as having good or moderate foliage density in 1996.

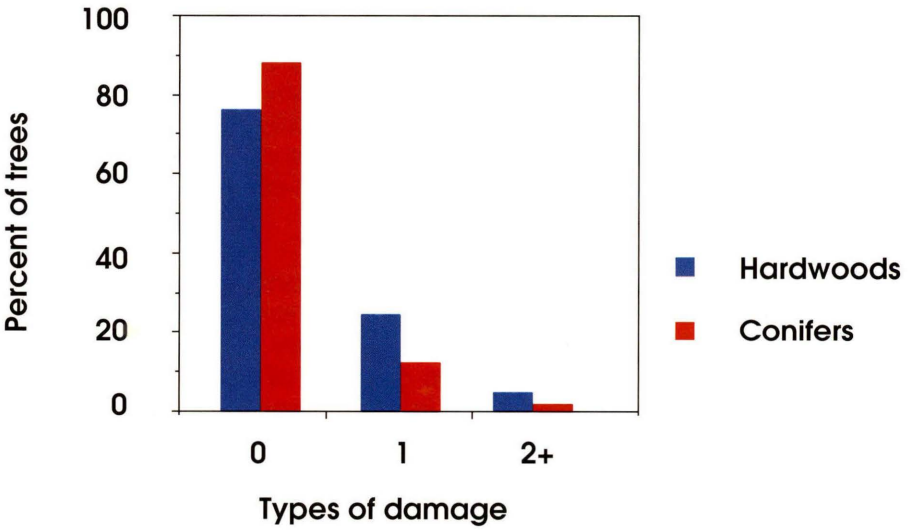
Damage to trees

Damage caused by diseases, insects, weather extremes, or other agents can have both positive and negative impacts on ecosystem health. A certain amount of damage is to be expected and is even desirable for the ecosystem in general. For example, holes in trees are used for shelter by wildlife and decaying wood harbors insects which are a major part of the food chain. However, sometimes the damage can be extreme, causing reductions in tree growth and increases in tree death.

In Forest Health Monitoring plots, information is collected on certain types of damage which may potentially kill trees. For each tree, type, location, and severity of damage is recorded. The purpose of this data base is to provide baseline information on how much and what types of damage are present. This is information against which future trends may then be compared. The graph below shows the amount of damage that trees have in the sample plots:



The majority of the trees in the sample plots have no visible signs of damage that threaten their long-term growth and survival. Of the 21% of trees with damage, decay is the most commonly observed type. Hardwood trees tend to have more damage than conifer trees, as indicated here in the 1996 data:



Ozone injury

Ozone is a gas formed both by natural processes and through human activities. Naturally formed ozone results from lightning during thunderstorms and by the action of sunlight on oxygen in the upper atmosphere. Human activities cause ozone formation because we burn fossil fuels in automobile engines and industrial enterprises. This burning process gives off hydrocarbons and nitrous oxides, which react with sunlight and lead to ozone formation near ground level.

Naturally formed ozone occurs mainly in the upper portions of the atmosphere. This ozone makes up the ozone layer, which shields us from harmful ultraviolet radiation. Ozone located in this layer is beneficial. On the other hand, ozone that is formed through human activities occurs in the lowest layer of the atmosphere. This ozone at the earth's surface can be damaging to plants and harmful to humans.

There is increasing concern about how ozone exposure is affecting the health of our forests. Ozone in the lower atmosphere is transported on air currents even to remote forest areas. Elevated concentrations of ozone in the eastern United States are common during the summer months when growing plants are most vulnerable to injury. Ozone is taken up by plant leaves during the process of photosynthesis. If conditions are suitable for rapid photosynthesis, such as presence of adequate moisture and warm temperatures, injury caused to the plant by high ozone levels may be especially great due to high ozone uptake.

Some plant species are especially sensitive to ozone and show clear signs of injury. They can be used as indicators of conditions that favor ozone injury to plants and therefore are known as bioindicators. The most useful bioindicator species in the North Central Region include milkweed, spreading dogbane, black cherry, and blackberry. Bioindicator species frequently show visible injury such as discoloration or spotting on the upper surfaces of their leaves from June to September. This discoloration varies among species and ranges in color from red or purple to brown. The effects of ozone on sensitive plants are cumulative, with symptoms becoming more noticeable and more severe in late summer. At this time, the susceptible plants often drop their leaves prematurely. Growth loss also has been documented in sensitive varieties of white pine, aspen, black cherry, and other species. The stress that plants can experience from exposure to ozone also increases their susceptibility to pests and other stress factors.

The Forest Health Monitoring Program examines biomonitoring sites associated with nearby forested plots. These biomonitoring sites are easily accessible openings that contain bioindicator species. These sites are visited yearly during a 15 day period in early to mid-August to determine the distribution and severity of ozone injury. Records of injury give a meaningful picture of plant exposure to ozone occurring across the region, as well as providing an indication of changes in air quality for the region.

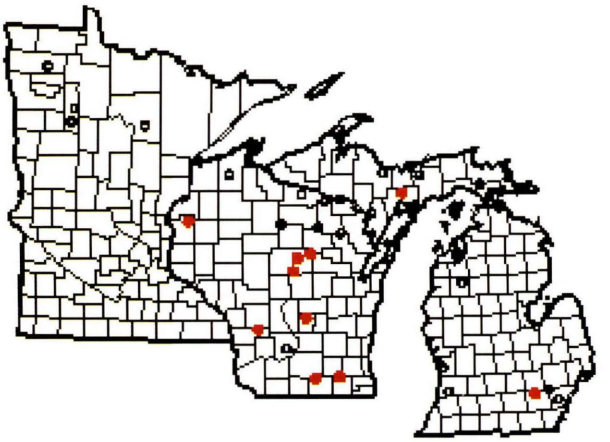
The maps on the facing page show the biomonitoring sites in the North Central Region where injury from ozone exposure has been recorded. In 1996, 4,172 plants on 100 sites were examined for symptoms of ozone injury. Over 94% of the plants had no symptoms of ozone injury. There was some amount of injury on 5.4% of all plants, but only 1.8% of all plants had more than 50% injury present.

Forest Health Monitoring plots evaluated for ozone injury in 1994, 1995, and 1996.

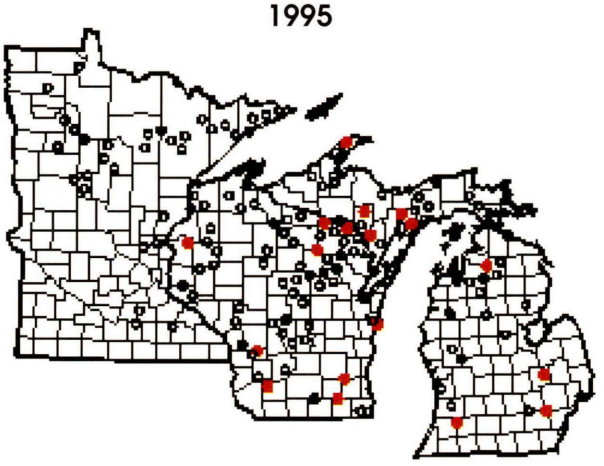
● Injury present

○ Injury not present

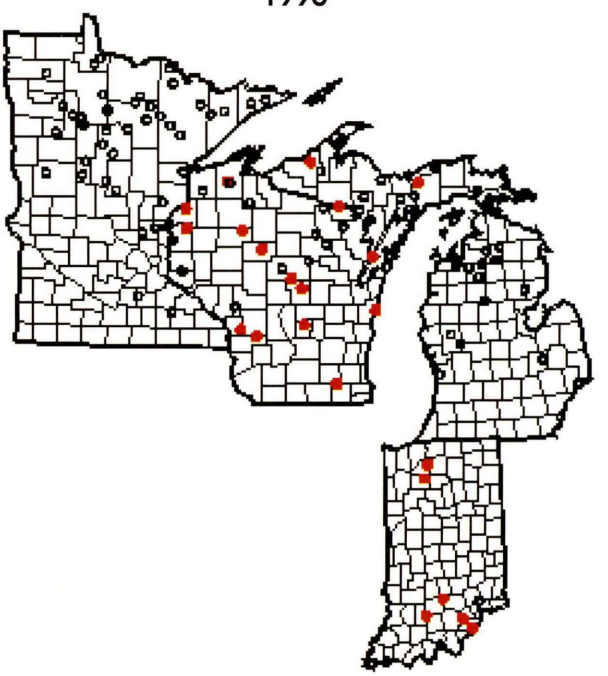
1994



1995



1996



III. What about specific problems and pests?

The overview

As we monitor conditions in the forest, we frequently encounter special problems caused by various stress factors. Common stress factors may be living organisms, such as insects, deer, or disease organisms. There are also many common stress factors that are nonliving such as fire, wind, drought, and pollution.

Sometimes damage from a given stress factor is very prevalent in a certain county, state, or region. When this is the case, surveys of the presence, activity, and biological consequences are conducted through a joint program between the federal government and the state(s) where damage is occurring. This program is known as the Cooperative Forest Health Protection Program. With the information collected in the forest-wide surveys made under this program, maps and reports are developed on an annual basis to inform land managers and others about the problems occurring in the forest.

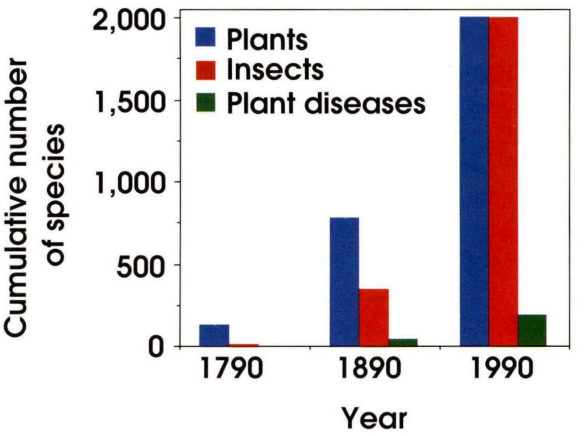
On the following pages, you will find some basic information about various living and nonliving stress factors that have recently been of major importance in the North Central Region.

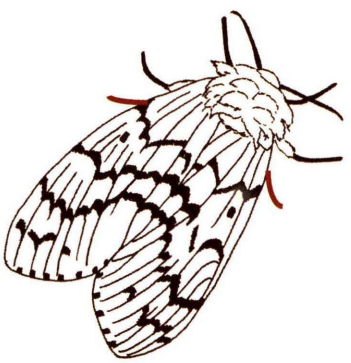
Exotic species

Sometimes an organism is found outside of its natural range. When organisms are found living in parts of the world where they are not native, these organisms are referred to as "exotic species" in that new location. Most organisms that reach new locations as exotics are transported to those locations by human activity. Many times, humans purposefully bring new species into an area. Other times, people move organisms about without really knowing it--for example, organisms may "hitch rides" on cars or ships or they may be found in fruits or wood or other cargo that is moved from one location to another.

It is estimated that at least 4,500 exotic species are now established in the United States. Many of these are very beneficial. Examples include most crop plants and domesticated animals that we raise, many types of sport fish, and many organisms that are natural enemies of important insect pests. However, exotic species also can be very harmful. They can become serious pests in the new areas where they have no natural enemies and plants have not developed resistance to the exotics. They may cause decline of native species with which they compete, alter structure and functioning of ecosystems, and lead to serious health concerns and economic loss for humans. The cumulative estimated loss due to selected harmful exotic insects in the United States from 1906-1991 was close to $93 billion.

Estimated cumulative numbers of exotic species in the United States





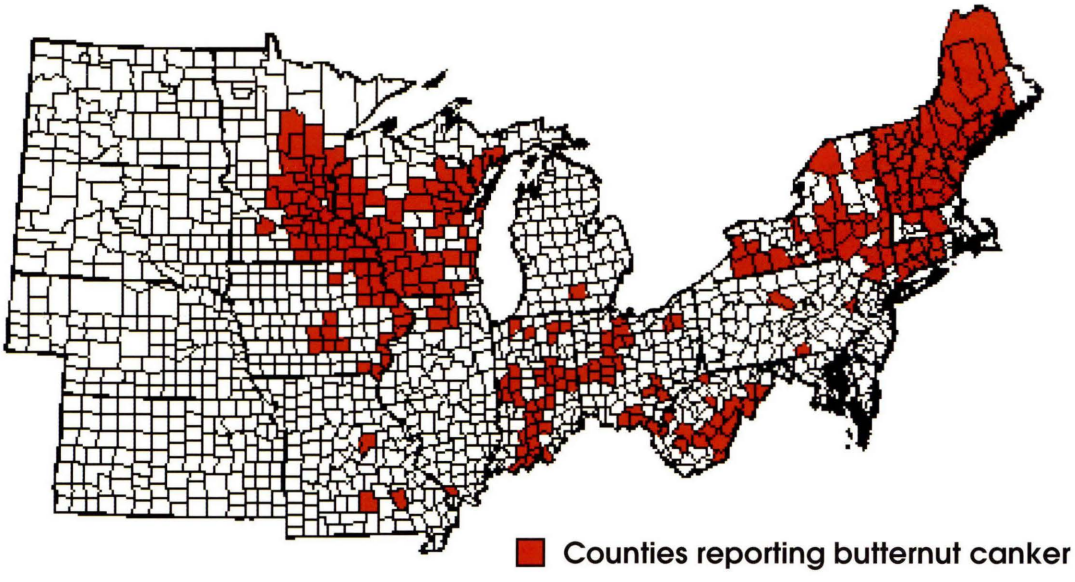
In American forests, exotic insects and disease organisms have been major pests and have caused much tree injury and death. Examples of important introduced pest species include chestnut blight, Dutch elm disease, white pine blister rust, common pine shoot beetle, pear thrips, and European gypsy moth. Exotic plant species such as honeysuckle, buckthorn, and purple loosestrife may compete with native plant species in American ecosystems. On the other hand, a variety of exotic species have been purposefully and successfully introduced to act as natural enemies of important forest pests and have greatly aided in control of these pests.

Butternut canker

Butternut canker is a fungal disease of butternut trees. We do not know whether this fungus is native or introduced or how long it has been in North America. Although first detected in Wisconsin in 1967, it was probably present much earlier.

Butternut trees are infected through buds, leaf scars, and possibly through insect wounds or other openings in the bark. When a tree is infected with this disease, patches of bark are killed. These dead areas, called cankers, can eventually encircle branches and stems and cut off the flow of water and food within the tree. This is called *girdling.* Reproductive structures of the fungus form in the cankers and are spread down the tree by rain water. As the number of infected sites on the tree increases, dieback in the crown accelerates. Heavily infected trees are killed.

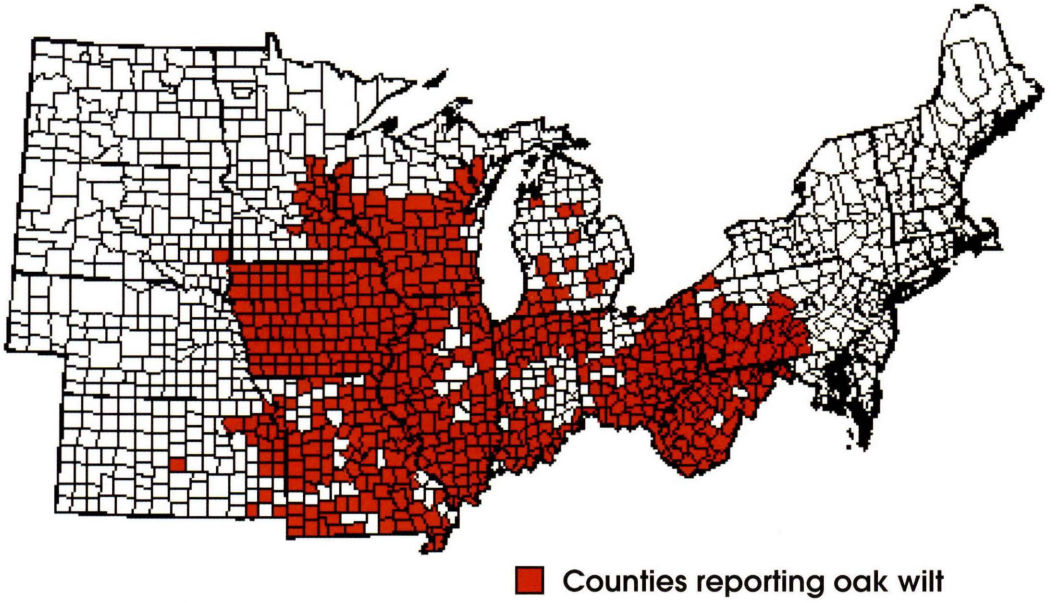
Butternut is a relatively minor component of forests in the eastern United States. The nuts, when present, are an important food source for some types of wildlife, and quality butternut wood currently ranks among the highest in value of all hardwood trees. Butternut also is important as a part of biological diversity in our forest. The map below shows areas of the forest where surveys have confirmed that butternut canker is present:



During the past 10 to 15 years, butternut canker has contributed to a dramatic decrease in the number of live butternut trees found in the United States. The decrease has been as much as 80% in some states. Management strategies for butternut canker in the eastern United States include monitoring efforts to assess the general health of butternut trees, conservation of certain individual butternut trees that may have resistance to this disease, and efforts to breed resistant strains of butternut.

Oak wilt

Oak wilt is a native fungus that invades oak trees and causes sudden wilting of the foliage. It is especially common on red oak, northern pin oak, and black oak. The disease is spread to new locations by sap-feeding insects that are attracted to wounds on oak trees. Oak wilt also can be spread by contact among root systems of adjacent trees. The range of oak wilt extends from Minnesota to Pennsylvania and North Carolina to central Texas. In the North Central Region, oak wilt continues to be a serious concern in Illinois, Indiana, Iowa, Minnesota, Missouri, and Wisconsin. In 1996, 7,200 acres of red oak mortality were reported in Minnesota. The distribution of oak wilt occurrence in 1996 can be seen in the map below:



Management options for oak wilt include educating the public about the fungus and developing guidelines for cutting and pruning oak trees. These guidelines include restricting cutting and pruning from April through June when insect transmission of the disease may occur. Also, a common technique used in urban areas is severing root grafts or joinings between infested and healthy trees using a vibratory plow. Since starting the oak wilt suppression program in Minnesota in 1991, over 130 miles of plow line have been installed to cut root system connections, and over 5,000 infected trees have been removed.

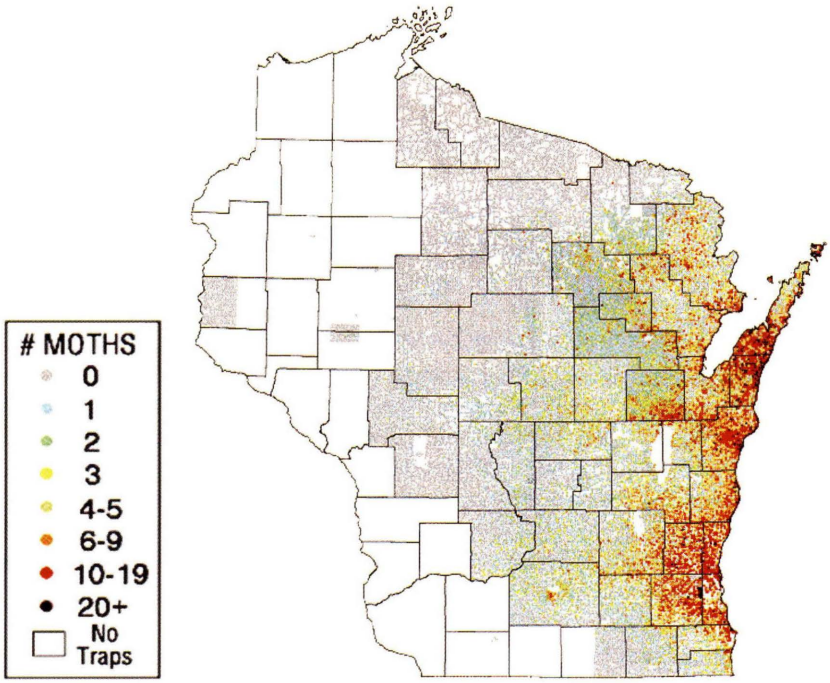
European gypsy moth

The European gypsy moth is an insect that was brought to the United States from Europe to improve silkworm populations through interbreeding. Although it proved unsuitable for this purpose, it became established near Boston, Massachusetts in 1869. It is now found from southern Canada to Virginia and west to Wisconsin, with a continually expanding range. Small isolated populations occur in a number of areas further west, such as Oregon, Washington, and California.

The gypsy moth causes damage through feeding activities only when it is in the caterpillar stage. It prefers feeding on hardwood trees, especially oaks, aspens, birches, basswood, witch-hazel, and willows. When populations of gypsy moth are at outbreak levels, the insects may feed on the leaves and needles of most tree species.

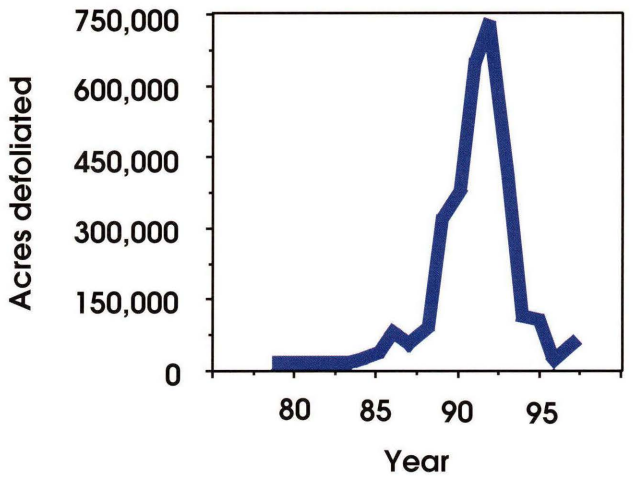
Feeding by the gypsy moth reduces the amount of leaf area that trees have available for food production, can lead to reduced tree growth, and may make trees more susceptible to other stress factors such as drought, frost, other insect pests, or diseases. The amount of damage caused by gypsy moth feeding varies depending upon the tree species, presence of other stress factors, and frequency and severity of defoliation. If defoliation is heavy and repeated in rural landscapes, various stress factors can lead to death of weakened trees and changes in the density and composition of forest stands. In suburban and urban areas, the gypsy moth causes aesthetic damage and is a nuisance to people, in addition to leading to reductions in tree vigor.

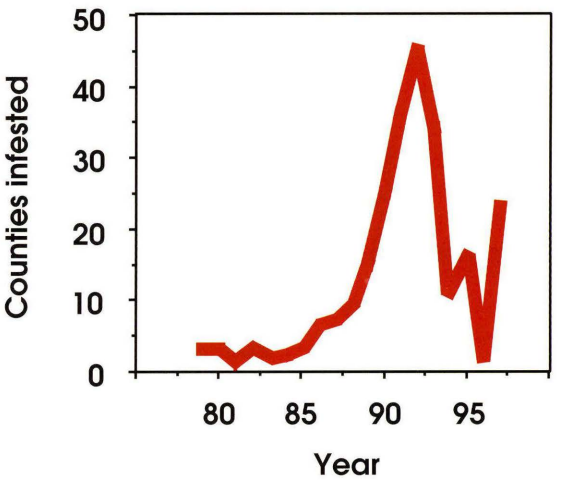
Gypsy moth populations and the damage caused by them have fluctuated over time. Pheromone traps (traps baited with the sexual attractant used by female gypsy moths to lure mates) are used for detecting populations and determining which areas are infested. The map below shows number of male moths caught per trap in 1996 in Wisconsin:



The states that make up the North Central Region routinely monitor for gypsy moths, identify isolated populations, and spray these areas in an attempt to prevent general infestation of the forests. In both Michigan and Wisconsin, the gypsy moth is a pest of special concern.

The gypsy moth has been in Michigan since 1952, but very little defoliation occurred before 1984. Defoliation increased and by 1992 was over 700,000 acres. However, defoliation dropped to 3,200 acres in 1996. This decline is due to a number of factors that combined to reduce gypsy moth population levels in the state. These factors include unusually cold winter temperatures, a naturally occurring virus of the gypsy moth (NPV), an introduced fungal disease of the gypsy moth (*Entomophaga maimaiga*), and sprays of microbial insecticides for the purpose of reducing nuisance and protecting foliage. In 1997, gypsy moth populations increased throughout Michigan. The fluctuation in defoliation by gypsy moth in Michigan during recent years can be seen below:





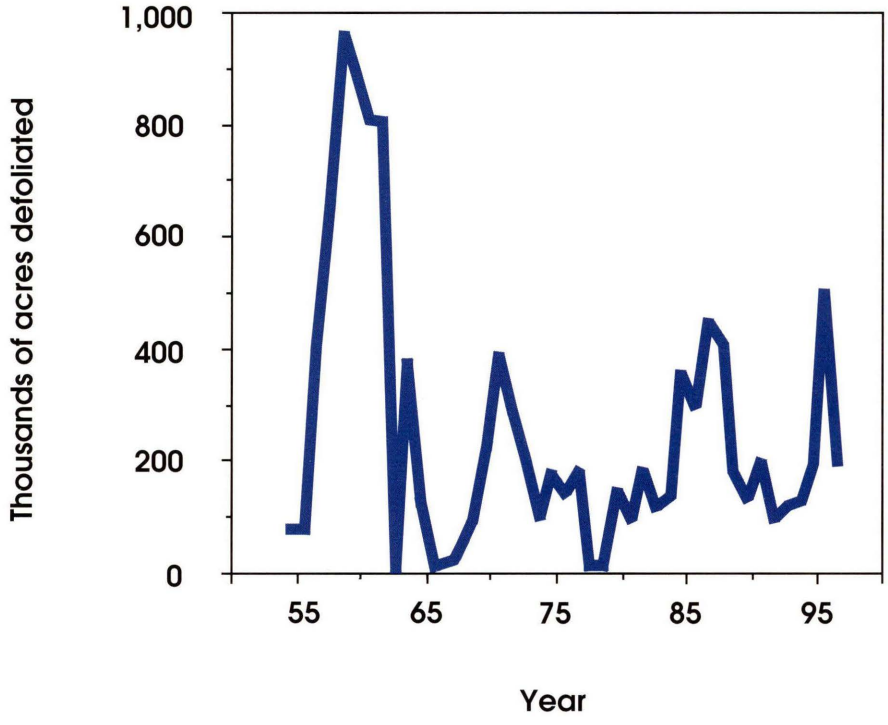
The number of counties affected by gypsy moth in Michigan increased from two in 1979 to 45 in 1993. In 1997, 23 counties in lower Michigan had significant defoliation.

Recently, reproducing populations of gypsy moth have been found in Wisconsin, but there has not been any noticeable defoliation there to date. Since 1990, over 218,000 acres have been sprayed in Wisconsin in an attempt to eradicate gypsy moth populations.

Management measures for gypsy moth in the North Central Region include monitoring to locate infested areas, spraying of isolated populations to eradicate them, spraying of generally infested areas to suppress nuisance to people and prevent excessive removal of leaves, applying appropriate management techniques to improve the health of oak stands, and educating the public about the gypsy moth.

Eastern spruce budworm

The eastern spruce budworm is a native moth that has lived in the spruce-fir forests of North America for many centuries. In the North Central Region, this insect can be found wherever balsam fir and white spruce grow. It has been especially important as a forest pest in the northernmost counties of Minnesota and Wisconsin and in the Upper Peninsula of Michigan. Major outbreaks of the spruce budworm occurred in the Lake States during the 1960s and 1970s, but populations declined in the early 1980s. Spruce budworm populations fluctuate a great deal. The data below shows defoliation in spruce-fir stands for the last 43 years in Minnesota:

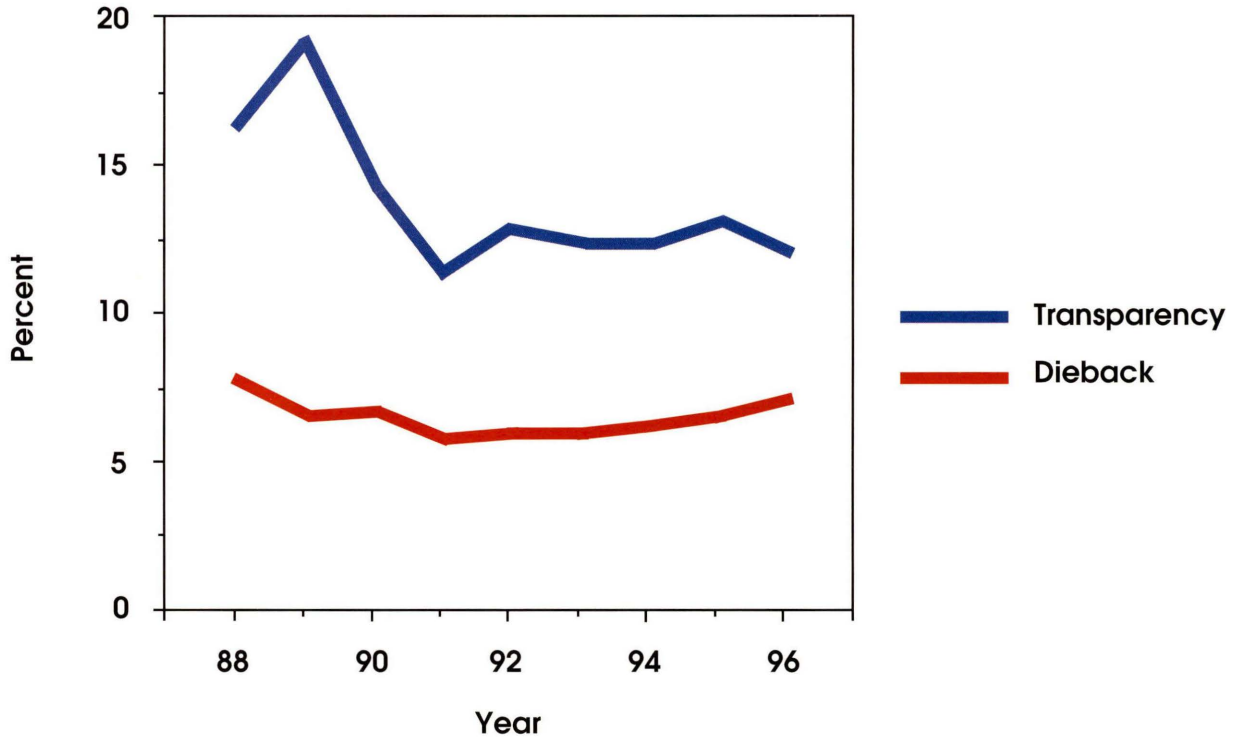


Impact of the spruce budworm on the forest depends on both the intensity and duration of the insect outbreak. The seriousness of the impact is also affected by the intended uses of the forest area where the outbreak occurs. Defoliation by the spruce budworm can result in growth loss, dieback of tree tops, and mortality of individual trees or whole stands of trees.

Management activities for the spruce budworm in the North Central Region include monitoring trends in spruce budworm populations, salvaging dying and dead trees before the wood becomes unusable, and decreasing the vulnerability of spruce-fir stands to this insect by using cutting techniques that enhance diversity of tree ages, structural diversity of the forest, and encourage plant species not susceptible to spruce budworm.

Maple stressors

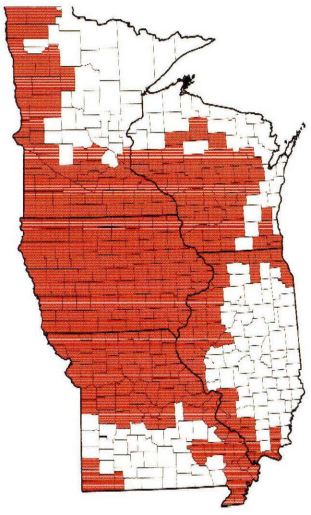
During the late 1970s and throughout the 1980s, maple syrup producers, land managers who managed northern hardwood forests, and the general public became concerned about the health of maple stands in relationship to acid rain and other disturbances. In response to these concerns, the North American Maple Project (NAMP) was formed in 1987 between Canada and the United States. The total number of forest stands monitored and evaluated annually by NAMP is 233. Geographic coverage extends from Minnesota and Ontario, south to Ohio and Pennsylvania, and east to Nova Scotia. Stands were selected to cover the range of major sugar maple growing areas, forest decline conditions, and site conditions. Approximately half of the plot clusters are in active sugarbushes (maple stands used for maple syrup production) and half are in non-sugarbushes. Sugar maple crowns are evaluated annually for dieback and foliage transparency. Results presented below are based on analyses of the crown conditions of over 9,000 mature, live sugar maple trees:



The overall condition of sugar maple trees at the NAMP sites is good. There is no difference in the condition of sugar maple in sugarbush and non-sugarbush stands. Both types of management regimes responded similarly to stress. Most improvements in crown condition between 1988 and 1996 are associated with recovery from various types of damage (forest tent caterpillar in Ontario, forest tent caterpillar and maple webworm in New York, pear thrips in Vermont and Massachusetts, and severe drought in 1987-1989 in Michigan and Wisconsin). Although crown conditions improved overall during the last nine years, numerous local disturbances caused by insect defoliators, drought, and wind have led to annual fluctuations in tree conditions in some regions. Mortality of trees in the overstory and understory layers of the forest have averaged 0.6% and 1.7% per year, respectively, since 1989. This annual mortality is within the normal variation seen as stands develop and age.

Weather

Weather patterns can have both positive and negative effects on forests. Mild weather with good moisture availability helps to promote good tree growth. However, many weather events are less favorable to tree health. The effects of weather-related stress may be mild branch dieback, overall loss of vigor in trees and a general sickly appearance, or even death of trees.

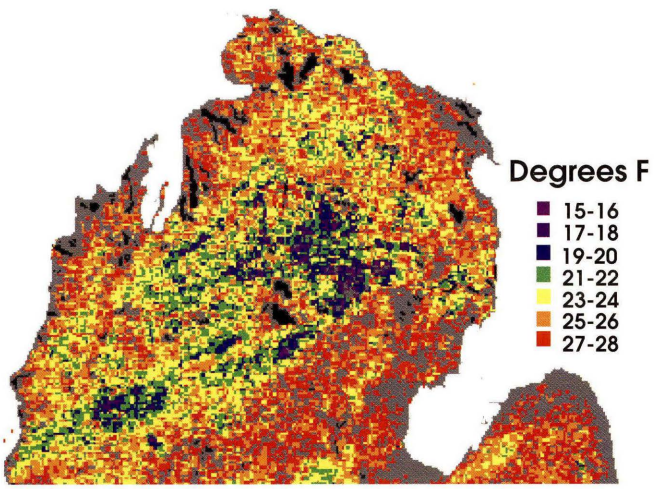


Counties declared flood disaster areas in 1993

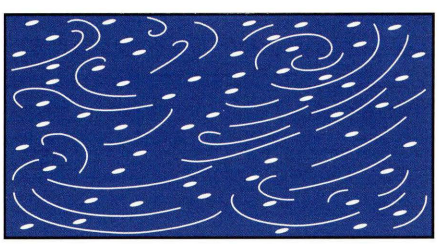
Moisture: The proper amount of moisture is very important in maintaining a healthy forest. Soils may become saturated in localized low-lying areas after heavy rains. Excess water can be a problem on a widespread basis when rivers flood. Although trees need water to grow, if their roots are submerged during the growing season trees can drown in the excess water and die. For example, over 11,000 acres of tree mortality occurred in Iowa in 1993 due to flooding.

Too little water also is a serious problem for trees. When low precipitation is combined with high temperatures for long time periods, drought stress can be severe. Trees may droop, foliage may look scorched, and trees may experience branch dieback or even death. Especially severe droughts occurred in the North Central Region during 1987-1988.

Temperature: Very high or low temperatures can both cause problems for trees. During late winter and early spring, temperatures at the surface of tree bark may fluctuate rapidly from very cold to warm as the bark is heated by the sun. Such temperature changes can promote cracks forming in trees. Tree buds that start to swell and grow early in the spring may also be harmed by sudden spring cold snaps. Frost can damage tender new tree leaves that have recently emerged and not had time to mature. Such frost stress can occur regularly in some low-lying areas. It can also occur more infrequently over widespread areas. For example, over 2 million acres in lower Michigan experienced severe frost stress during late spring and early summer in 1992.



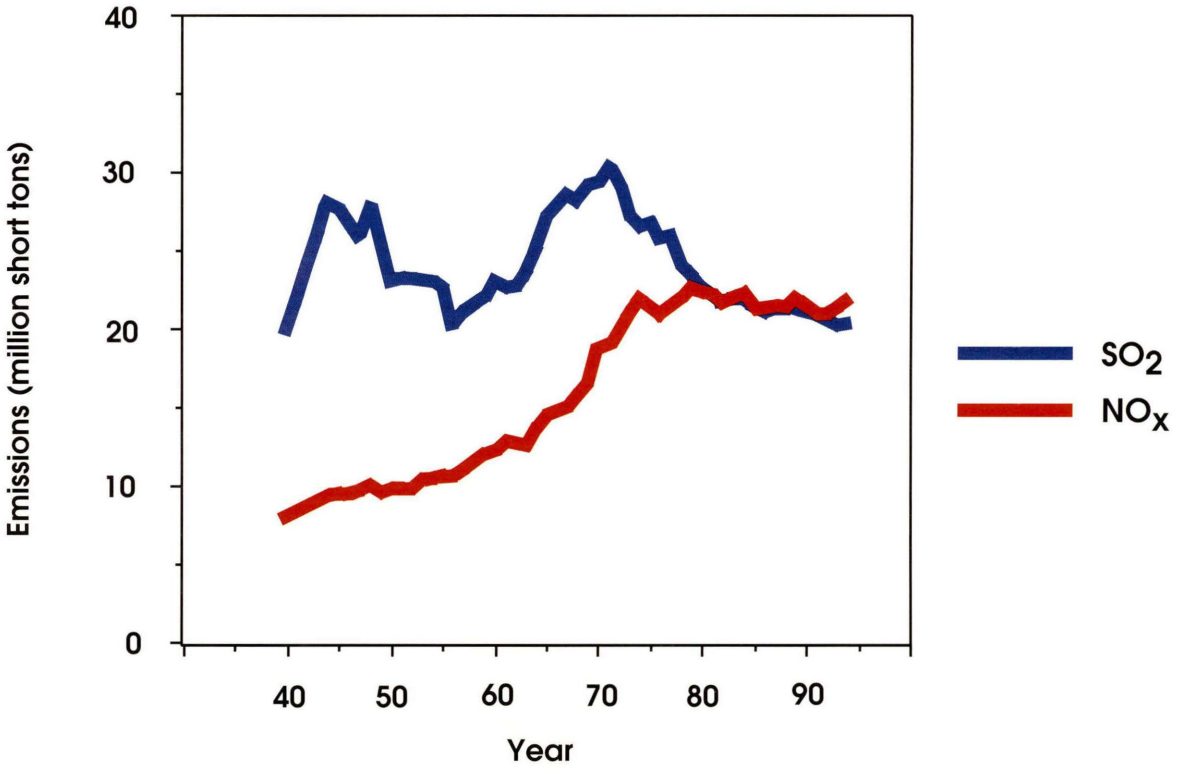
Northern Michigan temperatures on May 25, 1992



Wind: Strong winds that accompany storms can also present serious challenges for trees. Branches or portions of trees may be broken off by wind, or whole trees may blow over and be uprooted. Windstorms have been an important forest stress factor in the North Central Region. For example, windstorms in the forests of Minnesota in 1995 toppled an estimated 6.5 million trees.

Acid rain

A variety of atmospheric pollutants have long been of concern to people. In recent years, there has been a great deal of interest in those atmospheric pollutants that contribute to the formation of acid rain. Key pollutants involved are oxides of nitrogen and sulfur. The emissions of nitrogen oxides and sulfur oxides in the eastern United States have changed dramatically over time:



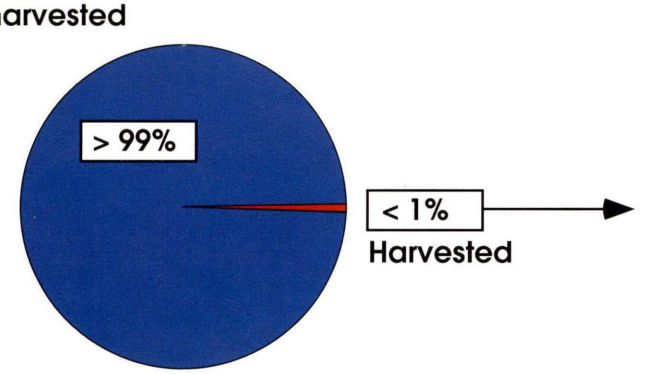
The rates of sulfur and nitrogen oxide emissions generally increased between 1900 and 1970 because of increased coal use, industrialization, emissions from electric power plants, and increased fossil fuel burning for transportation. After the passage of the Clean Air Act in the United States in 1970, emissions controls were put in place which led to decreases in sulfur oxide emissions.

The extent of effects from acid rain is still uncertain, and the matter is under further investigation. There is currently no evidence of a widespread decline in United States forests due to acid rain. However, acid rain is contributing to problems with forest health in certain localized regions where trees are exposed to highly acidic fogs and cloud masses on a frequent basis. There also may be subtle effects of acid rain on retention and cycling of nutrients through the forest and in the forest soils. It is possible as well that growth of young plants may be harmed by acid precipitation, leading to potential difficulties with normal forest regeneration.

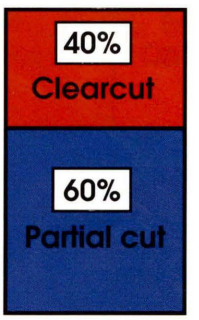
Clearcutting

Clearcutting is a type of tree harvesting in which all trees in an area are cut at the same time. In the North Central Region, jack pine and aspen stands are usually harvested by clearcutting. Some people do not like the appearance of clearcuts. However, this type of harvesting system and the kind of forest re-growth that it promotes are important in maintaining certain types of shade-intolerant tree species and the associated wildlife. For instance, grouse, woodcock, and deer thrive in the thick aspen stands that can regenerate in open, sunny, clearcut areas. To increase aesthetic appeal of the landscape, land managers strive to blend clearcuts in with the surroundings as naturally as possible. This is done by carefully regulating the size of the clearcut and by considering the shape of the opening so that the edges are somewhat natural in contour rather than being perfectly straight.

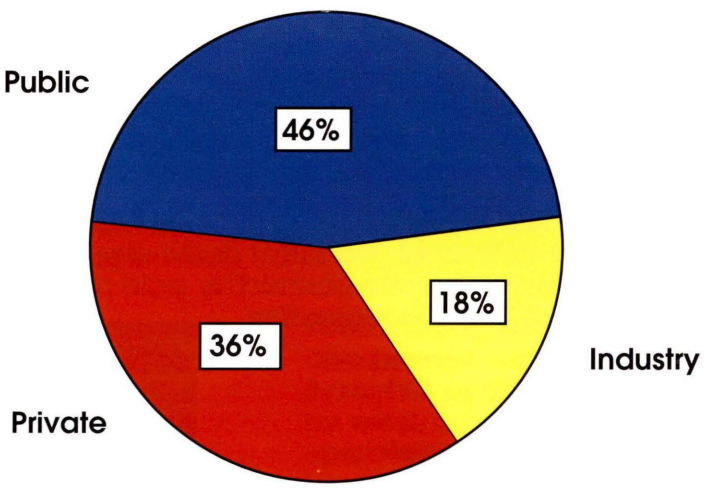
Of the total forested area in the North Central Region, the estimated fraction harvested each year from 1980-1990:



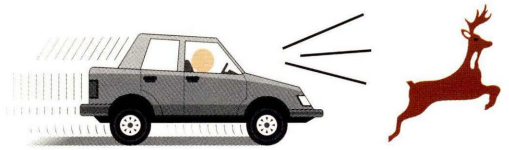
Of the total harvested area in the North Central Region, the estimated fraction clearcut each year from 1980-1990:



Estimated distribution of clearcutting among land ownership types in the North Central Region from 1980-1990:

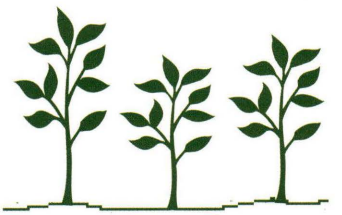


Eastern whitetail deer



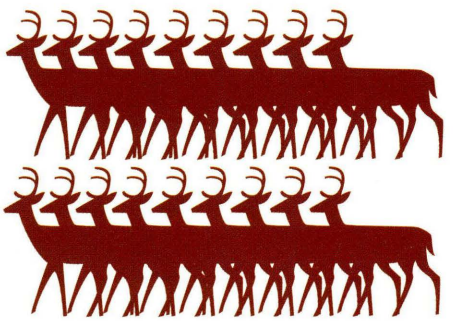
Deer/car accidents: The number of deer/car accidents has increased considerably during the past 10 years. Average loss from such accidents in Michigan in 1995 was $1,500.

Tree and shrub damage: Deer feed on trees and shrubs both in rural forests and in suburban communities. Excessive deer browsing in forests can lead to the selective removal of certain species, such as yew, and to difficulties with regeneration of various tree species, such as pines, oaks, and cedars.



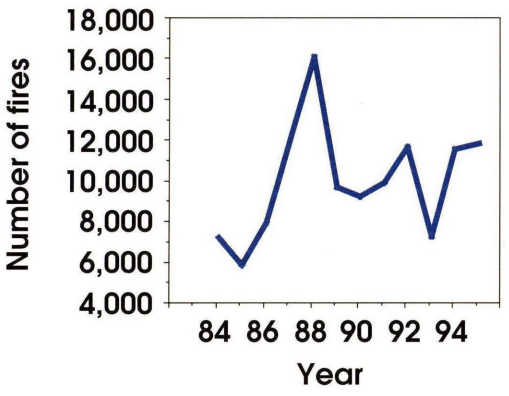
Crop damage: Often farm fields are interspersed with forested areas. Deer frequently feed on crops grown by gardeners and farmers. Crop damage from deer in the North Central Region has increased considerably in the last 10 years.

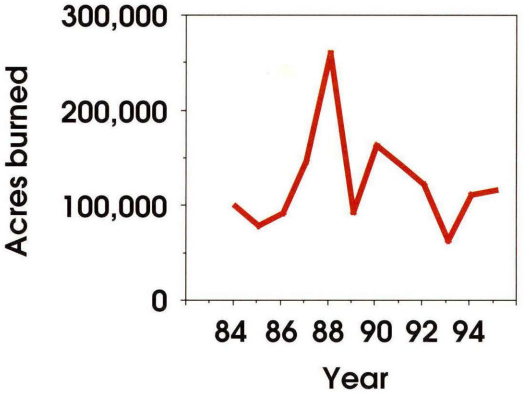
Overpopulation: Deer herds can readily build up to very high numbers. In some cases, this can lead to increased problems for humans because of the corresponding increases in deer/car accidents and plant damage. High deer population levels also lead to problems for the deer. Food can become scarce during harsh winter weather and many deer may starve. Also, parasites and diseases can become problems when deer are very crowded. A few of these diseases, such as bovine tuberculosis and Lyme disease, pose a concern for humans as well.



Forest fire

Estimated number of fires and acres burned in the North Central Region from 1984-1995:

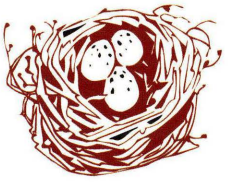




Although fires cost money to control, endanger lives, and damage property, periodic fires have benefits to natural systems:

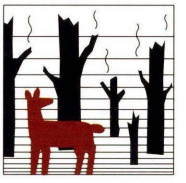
Fire bares mineral soil. Such bare mineral soil is needed by some plant species for their seeds to germinate. Also, some types of seeds need to be heated to high temperatures in order to sprout. Fires also release nutrients as they burn and this has a fertilization effect, allowing vigorous plant regrowth.

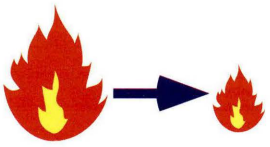
Fire impacts succession and helps to maintain the proper habitat conditions for early successional plant species. Grasses, wildflowers, berry plants like blueberries, and tree species like oaks and pines benefit from periodic fires.



Fire also helps to maintain appropriate habitat for animals associated with the fire-dependent plant species. For example, the endangered Kirtland's Warbler found in Michigan can only survive in the type of young pine ecosystem that is the result of a major disturbance like fire. Once the trees are about 10-15 years old, the habitat is no longer usable by the birds and they must find a different recently burned area.

Most animals can move fairly easily out of an area that is burning and find shelter in the surrounding ecosystems. They often move back into the burned area to feed on the abundant grasses and other plants that spring up soon after a fire.





Periodic fires are beneficial because they burn up the dead plant material on the forest floor. When fires are prevented and do not occur for long periods of time, the large amounts of fuel accumulated on the forest floor lead to very dangerous conditions. Any fire that accidentally starts will likely be much larger and hotter than would be the case if only low amounts of fuel were present on the forest floor. Therefore, frequent small fires greatly reduce the possibility of large disastrous fires.

IV. Summary

Maintaining healthy forests is very important ecologically, socially, and economically. We rely on forests to protect our air, water, and soil resources. Forests provide us with diversity in habitats and wildlife, and at the same time serve as important sources of timber. We turn to forests for aesthetic and recreational uses. Forests greatly affect our economy as well. They provide hundreds of thousands of jobs both directly and indirectly linked to the forest, its plant and animal products, and tourism in forest areas. More and more, people are coming to realize the great value that forests have for us and the important role that forests and their products play in our lives. With this realization comes an interest in forest health and in utilizing our forest resources wisely so that healthy forests will continue to be available for future generations.

Despite the increased interest in forest health and its obvious importance, the concept of a healthy forest has not been easy to define. It is a concept that involves not only scientific data but also a consideration of uses for forest areas, perceptions of various user groups and interested parties, judgement calls regarding the importance of various factors, and personal standards of what is appropriate and desirable in our natural world.

The Forest Health Monitoring Program is headed by the USDA Forest Service and carried out in cooperation with a variety of federal and state agencies and universities. It has been a major forest health monitoring and research initiative aimed at collecting scientific data on tree conditions and factors that damage trees. Extensive study of trees, insects, diseases, pollutants, and related factors has been carried out in permanent plots and other forest areas under this program.

In general, trees are in good condition throughout the forests of the North Central Region. On average, trees of most species score very well in terms of a number of variables that measure condition of the tree crown. Trees in this region also generally have little damage to their trunks. Some tree species and forest stands in certain areas are in poorer condition, and this is traceable to a variety of stress factors. A number of insects and diseases have stressed North Central forests to various extents. The most severe effects occur when the impacts of these organisms are combined with adverse weather conditions or other stresses such as pollutants or large forest fires. Stress also is often more severe when the organisms involved are not native, but are instead exotic species that have been imported from other parts of the world.

The Forest Health Monitoring Program, in combination with other research efforts, is helping us better understand the frequency, distribution, and effects of forest stress factors and provides us with a picture of current tree conditions in our forests. By continuing such monitoring programs and other research efforts, we will be well equipped to identify changes that occur in forest conditions and to recognize and track long-term trends. With this information, we will be even better able to manage our forests and keep our forests healthy.

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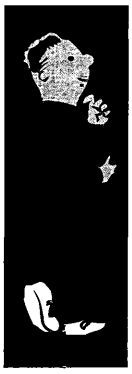

Want to know more?

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